New technologies attack soil, groundwater contamination

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Soil and groundwater contamination remains one of the most time-consuming and costly environmental remediation challenges. Scientists at the Department of Energy's Pacific Northwest National Laboratory have developed several technologies to effectively treat soils and groundwater plumes. Among them are three methods for treating problems in situ (in place), rather than physically removing the contaminants and dealing with them at another location.

These technologies are in-situ redox manipulation (ISRM), in-situ gaseous treatment (ISGT) and in- situ bioremediation. All are available now for use, license or exploration of co-development opportunities.

Initially, ISRM and ISGT were developed to treat contamination by chromium — specifically hexavalent chromium, or chromium (VI). According to *Environmental Health Perspectives*, a publication of the National Institute of Environmental Health Services, this form of chromium "is a primary contaminant at over half of all Superfund hazardous waste sites." It is a byproduct of industrial processes such as metal finishing, in which a natural chromium, chromium (III), is heated in the presence of mineral bases and atmospheric oxygen.

Redox manipulation

Recipient of an R&D 100 Award for innovation from *R&D Magazine*, ISRM is a patented groundwater remediation technology that involves the creation of an underground treatment zone that destroys or immobilizes contamination in place. ISRM works by injecting a solution of sodium dithionite into standard groundwater wells to reduce iron naturally present in the aquifer sediments from its ferric to its ferrous state. These reduced aquifer sediments are stationary within the aquifer and become the actual treatment zone for groundwater contaminants. Hexavalent chromium is immobilized as it migrates through the treated zone under natural flow conditions.

An important advantage of the ISRM technology is its long-term effectiveness, which minimizes operations and maintenance costs. An ISRM barrier can remain effective for up to 30 years and may be "rejuvenated" by re-injection of the dithio-nite solution using the original well network. Moreover, the ability of ISRM to treat deeper and larger contaminated plumes opens remediation options once thought technically and fiscally impractical.

Large-scale demonstrations at the DOE's Hanford Site have shown ISRM to be effective. Installation of a 2,300-ft treatment barrier is under way to intercept a hexavalent chromium plume located near the Columbia River. The final phase of this project is on schedule for completion in spring 2003.

ISRM also is being applied to a Superfund site near Vancouver, Wash. The plume was created decades ago when an electroplating plant discharged chromium-tainted wastewater into a well. Following a field test in October 2002, the Environmental Protection Agency selected the ISRM technology for full-scale deployment at this site.

PNNL is adapting the ISRM technology to other contaminants, including solvents and explosive compounds. Initial field testing at a site on the Ft. Lewis, Wash., U.S. Army post showed encouraging results for the in-situ destruction of trichloroethylene.

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Gaseous treatment

ISGT is a cost-effective alternative to excavation and removal for contaminated soils. The approach is particularly suitable for sites with contamination located at depths greater than 15 feet. This approach immobilizes or destroys contaminants in soils above the water table.

The technology involves injecting chemically reactive gas mixtures into the soil, destroying or immobilizing contaminants in place. For contaminants that may be reduced to non-toxic forms, a diluted hydrogen sulfide gas mixture is injected into the soil through a central borehole. The gas mixture is then drawn through the waste site by vacuum extraction boreholes located along the perimeter of the site. Reactive gas samples are monitored in the extraction wells to provide a real-time basis for tracking remediation progress.

In a cooperative effort between the DOE and the Department of Defense, PNNL researchers field-tested ISGT at the White Sands Missile Range in New Mexico by injecting hydrogen sulfide into chromate-contaminated soils. Final performance assessment findings showed that 70 percent of the chromium (VI) present at the site was reduced to a non-toxic form, chromium (III).

Laboratory tests indicate that ISGT also can be useful for immobilizing other metals, including cadmium, mercury and lead, as well as radionuclides such as uranium and technetium. PNNL is seeking industrial partners to collaborate in pursuing this promising technology.

Bioremediation

Biological processes can degrade or transform a wide range of contaminants into non-hazardous compounds. PNNL has developed and applied in-situ bioremediation techniques for chlorinated solvents and hydrocarbon contaminants. In-situ bioremediation can be applied as either monitored natural attenuation or accelerated in-situ bioremedia-tion.

Monitored natural attenuation is a remedy in which natural processes such as biodegradation, dispersion and adsorption reduce contaminant levels without human intervention. Regulatory acceptance of monitored natural attenuation as a remedy requires that the natural attenuation processes will meet remediation goals for the site.

In accelerated in-situ bioreme-diation, nutrients are added to an aquifer to stimulate the growth of bacteria that can destroy the contaminant through microbial processes. PNNL has applied this technique to successfully treat carbon tetrachloride and mixtures of chlorinated solvents at a number of federal sites.

PNNL has developed a bioreme-diation simulator (Reactive Transport in 3-Dimensions — RT3D) for the design of accelerated in-situ bioremediation projects. RT3D also has been used to assess monitored natural attenuation at various Department of Defense and National Priority List sites.

For example, at the Point Mugu Naval Air Station in Ventura County, Calif., a leaking underground storage tank had contaminated about two acres of groundwater with trichloroethene and dichloroethene. RT3D was used to design a pilot-scale test to evaluate the effectiveness of two microbial processes within the contaminated aquifer. The design was successfully field- tested and resulted in complete degradation of contaminants

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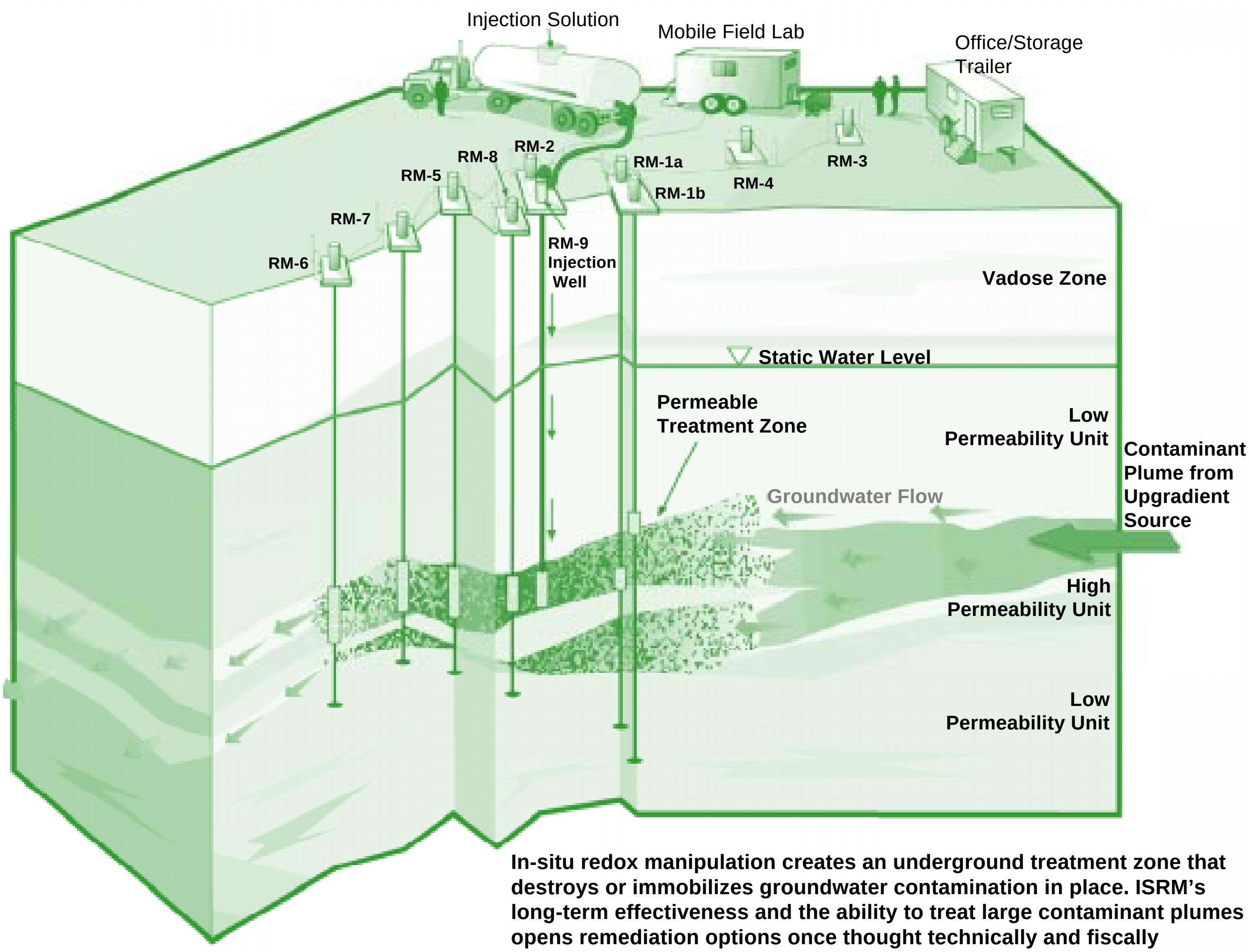
to non-hazardous compounds. RT3D is publicly available; see **http://bio process.pnl.gov/rt3d.htm** for details.

In-situ redox manipulation, in-situ gaseous treatment and in-situ bioremediation are proven cleanup technologies for contaminated ground-water and soils. For details on these and other PNNL-developed environ-mental remediation technologies, contact me, Joseph Devary, at 376-8345 or at joe.devary@pnl.gov. ■



In-situ redox manipulation creates an underground treatment zone that destroys or immobilizes groundwater contamination in place. ISRM's long-term effectiveness and the ability to treat large contaminant plumes opens remediation options once thought technically and fiscally impractical.